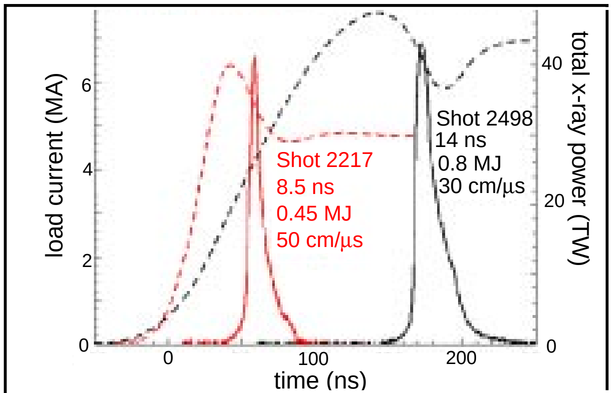
May 1998 Highlights of the Pulsed Power Inertial Confinement Fusion Program



Current and radiated power for short and long pulse Saturn modes. The slower implosion on Shot 2498 produces 1.8 times the x-ray energy in a 170-ns implosion. The pinch diameter at peak power, 0.7 mm, represents a 36:1 compression ratio. Shot 2217, with the tightest pinch in the short pulse mode, had an 18:1 compression ratio. Load current data from Bdot monitors have been used to create a circuit model for the long pulse mode.

A workshop on fast and slow pulsed power for stockpile stewardship was held May 12-14 in Las Vegas. In Saturn experiments, we produced high-quality, high-radiated-energy z pinches from long-implosion-time loads. We had 15 Z shots in May: six with a dynamic hohlraum to test new diagnostics with optically-thin azimuthal slots, six to optimize the x-ray flux to an on-axis secondary, and three in a six-shot dynamic hohlraum series with nested arrays and a closed return current can.

The present Z shot rate is dictated by installation of diagnostics for different experiments. With the increased usage by distinct researchers for a variety of experiments with differing needs, we are moving toward a more formal review process for shot requests and planning. Modernization plans include adding six more cryopumps to decrease the time to achieve vacuum conditions between shots and replacing the remaining aluminum transmission lines in the water section with stainless steel to reduce maintenance.

We demonstrated a long pulse mode on the lower-current (10-MA) Saturn accelerator to generate intense soft x rays. By shorting the water output switches, the risetime of the load current was increased from 50 to 230 ns, delivering nearly twice the energy into the vacuum section compared to the usual short pulse mode. The fast rise time and high radiated power for the slower implosion velocity is an important result (see figure) for optimizing sources for the 60-MA X-1, since it will be designed for variable pulse lengths and the loads for the longer implosion time will reduce the cost and power flow risk. Shot 2498 had 300, 5.1-µm-diameter tungsten wires in a 25-mm-diameter array; Shot 2217, taken in January 1996, had 70, 7.5-µm-diameter wires in a 12.5-mm-diameter array.

The shots this month to optimize the radiation delivered to an on-axis secondary use a foam-filled, thin-walled copper cylinder within a double nested array of tungsten wires. A closed return current can minimizes the perturbation of the imploding wire plasma. The annular or solid low-density CH foam enhances the on-axis radiation drive. We are analyzing the data obtained to understand how the mass of the annular foam layer affects the radiation delivered to the secondary.

NRL is studying the early z-pinch dynamics of a linear tungsten array for various levels of prepulse current and wire heating to determine the best conditions for implosions on Z. These conditions at early time affect the subsequent pinch behavior, including instability growth, final pinch diameter, and, ultimately, the achieved x-ray power. The high-density wire plasma core and low-density plasma corona are observed with shadowgraph and Schlerien techniques. The results agree qualitatively with Imperial College's coronal plasma images of linear arrays of carbon fibers and copper wires and with Cornell's x-ray backlit images of single tungsten cores. The plasma density of the corona and core is sensitive to the duration of the prepulse current but less sensitive to its magnitude. Preheating the wires white hot before an electric discharge at about the Z prepulse level (5 kA/wire) reduces the observed axial nonuniformity of the core plasmas and should produce a tighter pinch, but may be impractical on Z.

Hardware, diagnostics, and the chamber wall on the proposed X-1 will require additional protection during the 1 - 2 shots a month that generate high fusion yield (200 MJ or greater). As part of the X-1 planning process, SRI International reviewed 2D simulations of material penetration by debris and shrapnel, based on energy scaling of experiments done on Nova and the Phoebus laser at CEA in France, in designing the NIF chamber. Such experiments must be done on Z for X-1 because of the higher energy expected and the differences in the debris and shrapnel that are generated in a pulsed power environment.

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